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Waste-Soil Design Ratio Calculations

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This calculation analyzes different types of potential debris that are anticipated to be disposed at the INEEL CERCLA Disposal Facility landfill. The calculation determines the amount of soil that will be required to provide a stable fill that will protect the permanent cover system for the landfill.

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ABSTRACT

This calculation analyzes different types of potential debris that are anticipated to be disposed at the INEEL CERCLA Disposal Facility landfill. The calculation determines the amount of soil that will be required to provide a stable fill that will protect the permanent cover system for the landfill.

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CQA	construction quality assurance
DOT	Department of Transportation
EDF	engineering design file
EPA	Environmental Protection Agency
INEEL	Idaho National Engineering and Environmental Laboratory

Waste-Soil Design Ratio Calculations

1. INTRODUCTION

The purpose of this calculation is to analyze the minimum volume ratio of contaminated soil waste to debris waste that will not impact the long-term performance of the cover system.

1.1 Input Data

The following sizes of containers and/or debris were used in this calculation:

- 4 ft × 4 ft × 8 ft steel or wood box.
- 4 ft × 4 ft × 4 ft steel or wood box.
- Building demolition debris will consist of steel beams, drill stem, concrete rubble, flattened or cut-up tanks, pipe, etc. Sizes evaluated for beams were 1.5 ft wide × 1.5 ft deep × 20 ft long; for concrete rubble were 12 in. in diameter and up to 4 ft × 4 ft × 1 ft; it was assumed other debris could be crushed during placement and not require a significant amount of soil to allow proper disposal.
- Standard Department of Transportation (DOT) drums.
- 8 ft × 10 ft × 3 ft concrete monoliths.

1.2 Assumptions

The following assumptions were used in performing these calculations:

- No debris will be placed in the 5 ft of wastes immediately above the operations layer, in the 5 ft of wastes below the final waste elevation, and in the 50 ft of wastes adjacent to the sides of the landfill.
- Disposal of debris has been based on spreading debris out to allow complete soil coverage and thus rely on proper compaction of soil for supporting cap and not on strength of debris.
- Steel boxes were assumed to be completely filled and therefore uncompressible.
- Wooden boxes were assumed to be collapsed during landfill operations.
- Building debris was assumed to be in pieces that could be placed flat in the landfill and not a tangled mass that would be compressible as additional fill is placed.
- Compaction of debris, except for drums, will be performed with a vibratory compactor and not small, hand-operated equipment.

2. CALCULATION

This calculation develops the minimum soil to debris ratio for 4 ft × 4 ft × 8 ft boxes. As shown in Figure 2-1, minimum spacing between boxes is 10 ft to allow compaction of soil using a compactor. Boxes can be wood or steel.

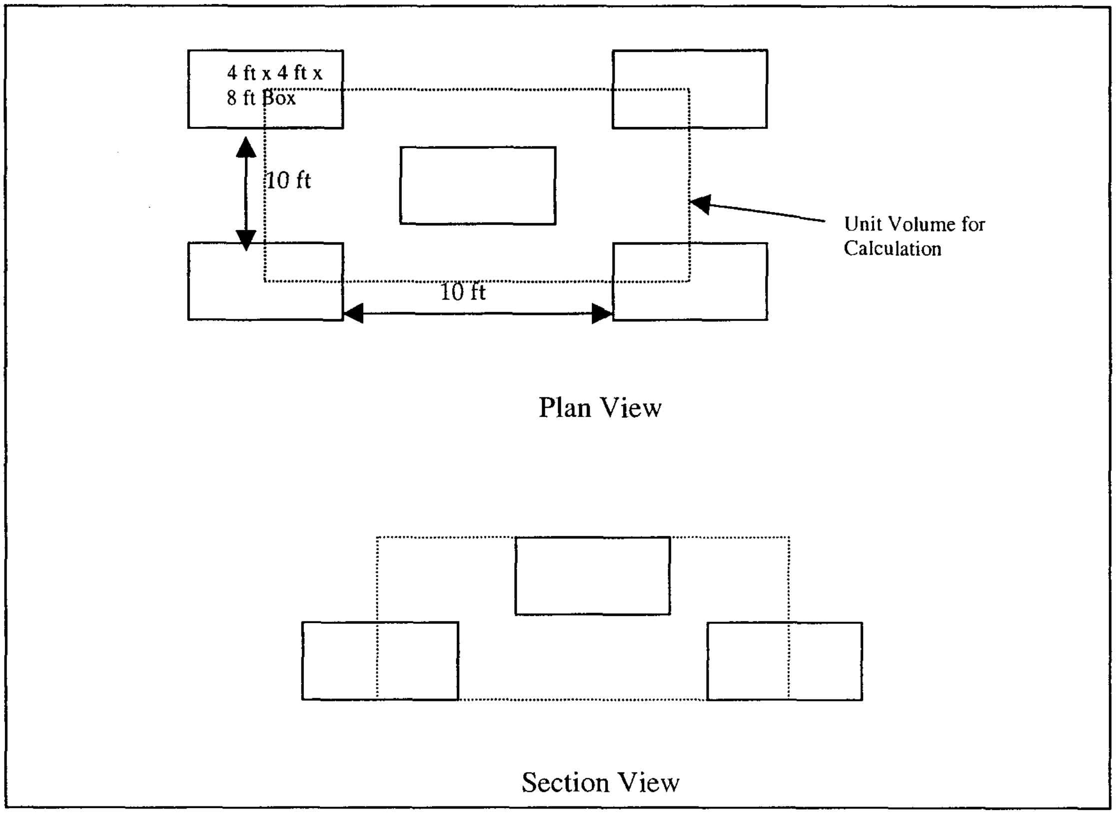

Figure 2-1. Plan and section views for 4 ft × 4 ft × 8 ft boxes.

Total unit volume for basis of calculation = (14 ft)(18 ft)(8 ft) = 2,016 ft^3

Total volume of debris boxes within the total unit volume = (4 ft)(4 ft)(8 ft) + 4[(2 ft)(4 ft)(4 ft)]

Total volume of debris boxes = 256 ft^3

Total volume of soil = 2,016 ft^3 – 256 ft^3 = 1,760 ft^3

Minimum soil: Debris ratio = 1,760 ft^3/256 ft^3 = 6.9.

This calculation has been developed based on the boxes being filled completely with debris. Only wooden boxes that can be crushed and that were not filled to the required limit identified in DOE-ID 2002a will be allowed in the landfill. For boxes that were not filled to the required limits identified (DOE-ID 2002a), only wooden boxes that can be crushed will be allowed into the landfill. If the wooden boxes are crushed during placement, additional soil volume will be required compared to that calculated above. As boxes are crushed, the resulting debris materials will be handled and placed in a manner that eliminates void spaces in the waste and produces a stable waste fill.

This calculation develops the minimum soil to debris ratio for 4 ft × 4 ft × 4 ft boxes. As shown in Figure 2-2, minimum spacing between boxes is 10 ft to allow compaction of soil using a compactor. Boxes can be wood or steel.

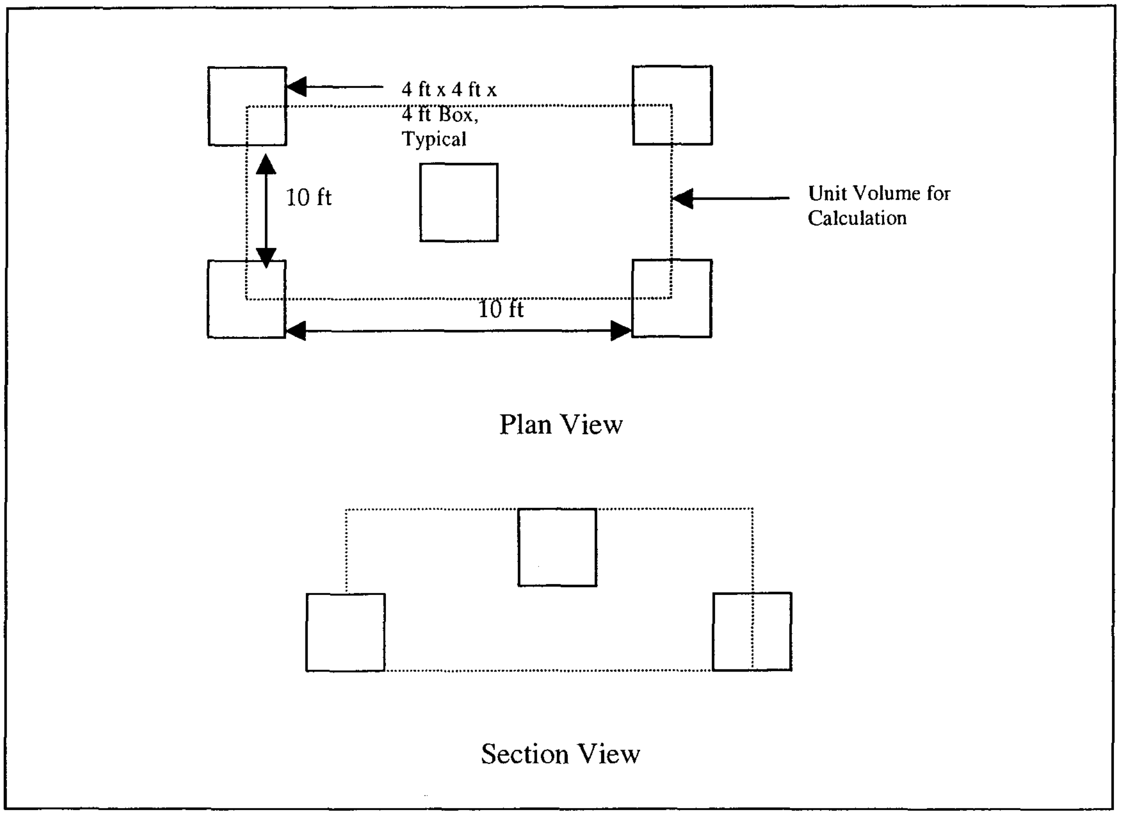

Figure 2-2. Plan and section views for 4 ft × 4 ft × 4 ft boxes.

Total unit volume for basis of calculation = (14 ft)(14 ft)(8 ft) = 1,568 ft^3

Total volume of debris boxes within the total unit volume = (4 ft)(4 ft)(4 ft) + 4[(2 ft)(2 ft)(4 ft)]

Total volume of debris boxes = 128 ft^3

Total volume of soil = 1,568 ft^3 – 128 ft^3 = 1,440 ft^3

Minimum soil: Debris ratio = 1,440 ft^3/128 ft^3 = 11.

This calculation has been developed based on the boxes being filled completely with debris. Only wooden boxes that can be crushed will be allowed in the landfill that were not filled to the required limit identified in DOE-ID 2002a. If the wooden boxes are crushed during placement, additional soil volume will be required compared to that calculated above. As boxes are crushed, the resulting debris materials will be handled and placed in a manner that eliminates void spaces in the waste and produces a stable waste fill.

This calculation develops the minimum soil to debris ratio for steel/concrete beams. As shown in Figure 2-3, horizontal and vertical spacing between beams is a minimum of 1 ft to allow for a soil envelope around debris. Sizes evaluated for beams were 1.5 ft wide × 1.5 ft deep × 20 ft long. This beam calculation also applies for drill stem, which is similar to disposal of beams. Maximum length of 20 ft was assumed for drill stem.

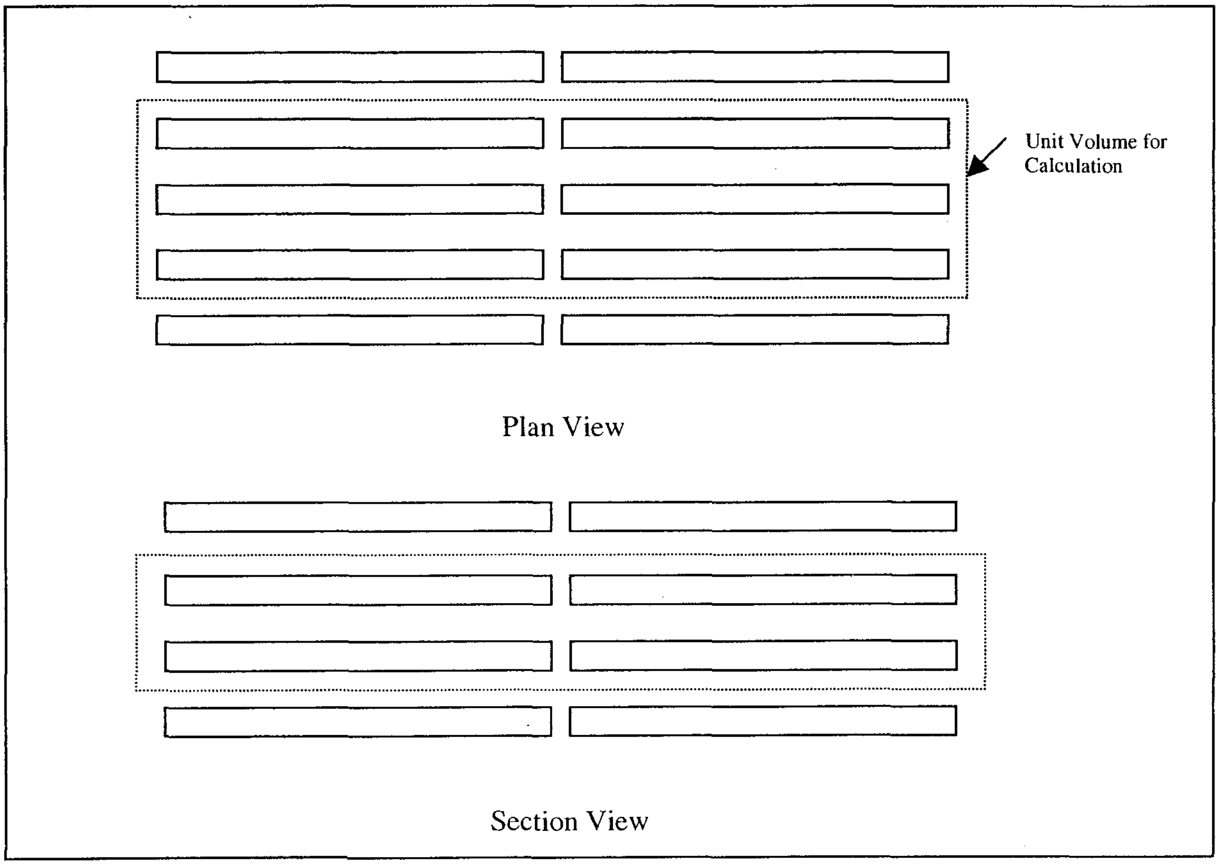

Figure 2-3. Plan and section views for steel/concrete beams.

Total unit volume for basis of calculation = (42 ft)(7.5 ft)(5 ft) = 1,575 ft^3

Total volume of debris within the total unit volume = 12[(1.5 ft)(1.5 ft)(20 ft)]

Total volume of debris = 540 ft^3

Total volume of soil = 1,575 ft^3 – 540 ft^3 = 1,035 ft^3

Minimum soil: Debris ratio = 1,035 ft^3/540 ft^3 = 2.

This calculation develops the minimum soil to debris ratio for concrete debris such as concrete wall demolition. As shown in Figure 2-4, calculate for 4 ft × 4 ft × 1 ft size pieces. Use minimum 1 ft vertical and horizontal separation of concrete pieces. This calculation applies to relatively thin pieces of concrete such as walls, etc. that are less than 12 in. thick. This size of material can be placed flat in the landfill, covered with waste soil, and compacted to provide a stable fill. Pieces of concrete/debris thicker than 12 in. will be handled as described for concrete monoliths. This calculation also applies to the disposal of tanks in the landfill. Small tanks should be flattened for disposal to minimize voids. Large tanks should be cut into pieces similar to the sizes used in this calculation.

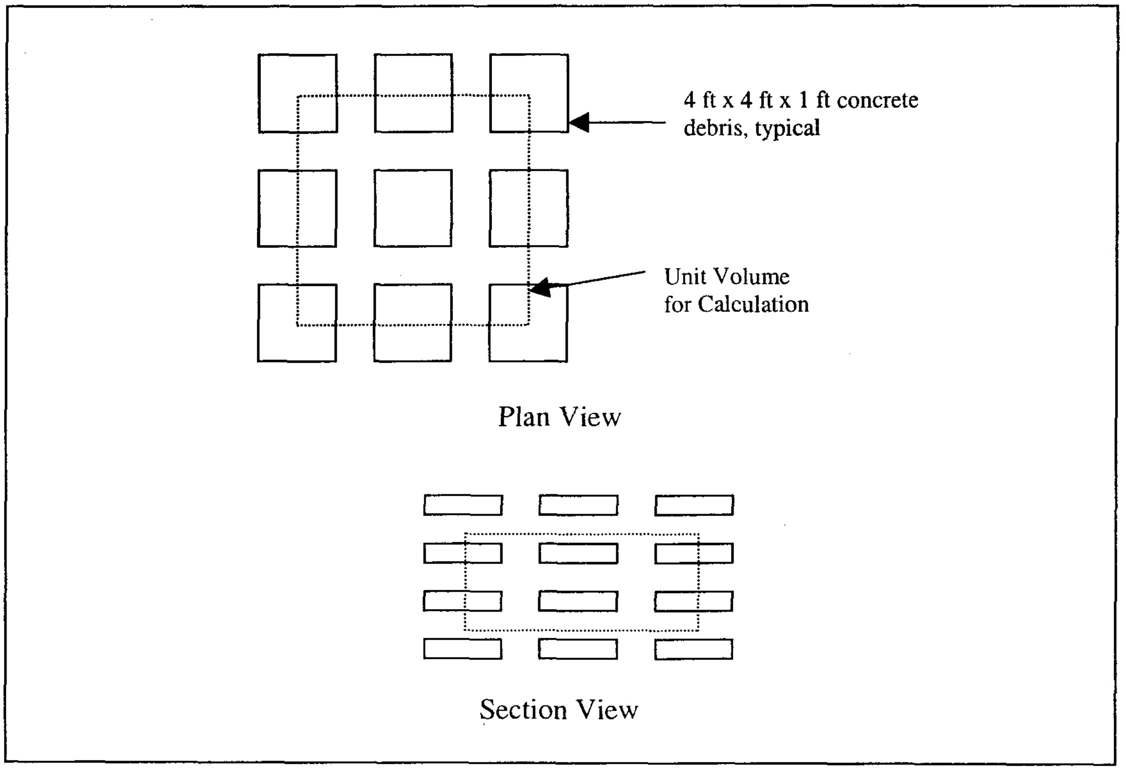

Figure 2-4. Plan and section views for concrete debris.

Total unit volume for basis of calculation = (10 ft)(10 ft)(4 ft) = 400 ft^3

Total volume of debris within
the total unit volume = (4 ft)(4 ft)(1 ft) + 4[(2 ft)(2 ft)(1 ft)] + 4[(2 ft)(4 ft)(1 ft)]

Total volume of debris = 64 ft^3

Total volume of soil = 400 ft^3 – 64 ft^3 = 336 ft^3

Minimum soil: Debris ratio = 336 ft^3/64 ft^3 = 5.3.

This calculation develops the minimum soil to debris ratio for concrete rubble. As shown in Figure 2-5, calculate for 12-in.-diameter rubble size. This calculation assumes that small concrete and building rubble will be placed with a minimum of 1 ft horizontal and vertical spacing between rubble loads. Individual rubble loads will be spread out, as necessary, to ensure proper filling of voids with soil. An average rubble size of 12 in. is assumed, along with an average spacing of 1 ft between pieces.

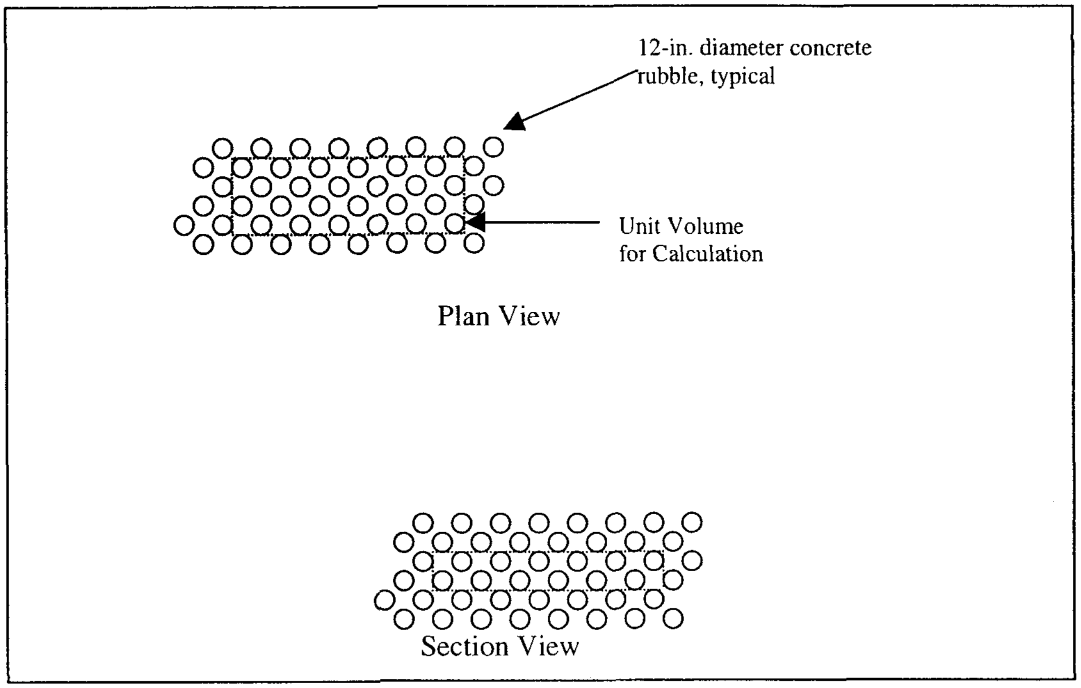

Figure 2-5. Plan and section views for concrete rubble.

Total unit volume for basis of calculation = (12 ft)(4 ft)(2 ft) = 96 ft^3

Total volume of debris within the total unit volume = $48[\pi(0.5\ ft)^3(4/3)]$

Total volume of debris = 25.1 ft^3

Total volume of soil = 96 ft^3 – 25.1 ft^3 = 70.9 ft^3

Minimum soil: Debris ratio = 70.9 ft^3/25.1 ft^3 = 2.8.

This calculation develops the minimum soil to debris ratio for disposal of drums. As shown in Figure 2-6, calculate for standard DOT drum (2 ft diameter × 3 ft tall).

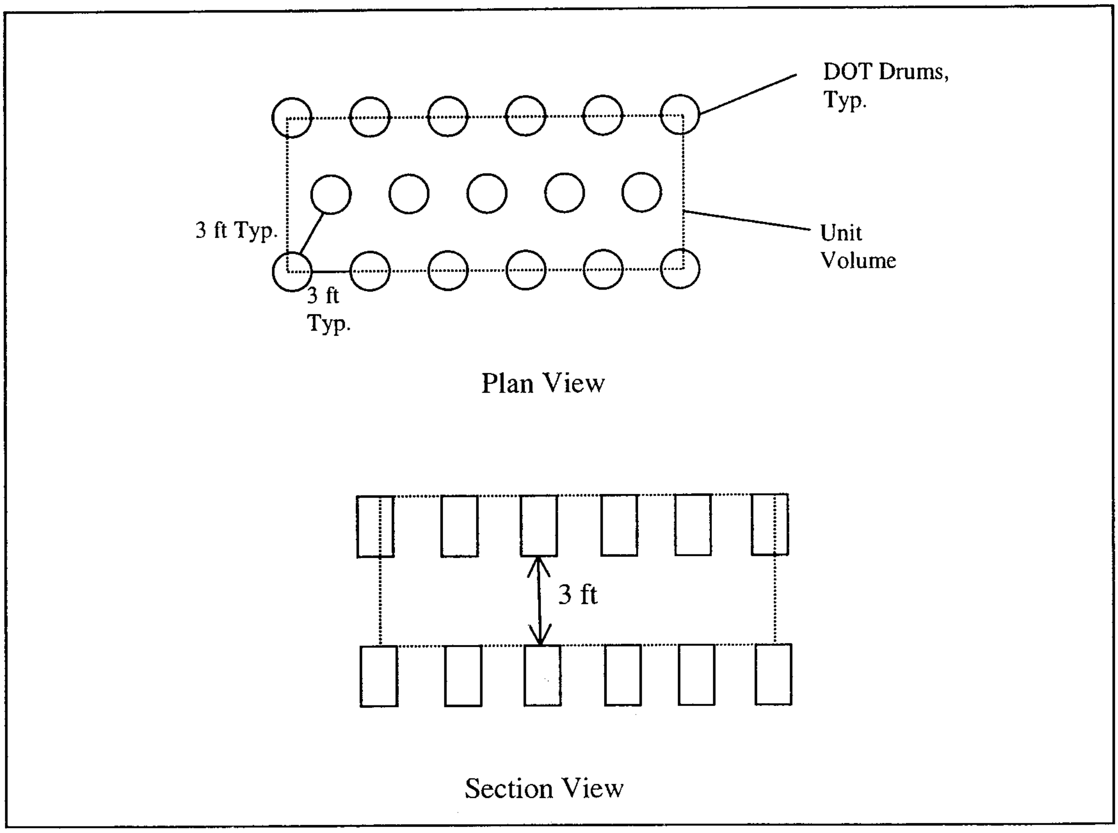

Figure 2-6. Plan and section views for disposal of drums.

Total unit volume for basis of calculation = (10 ft)(25 ft)(6 ft) = 1,500 ft^3

Total volume of drums/debris within the total unit volume = 10 drums (9.42 ft^3) = 94.2 ft^3

Total volume of soil = 1,500 ft^3 – 94.2 ft^3 = 1405.8 ft^3

Minimum soil: Debris ratio = 1405.8 ft^3/94.2 ft^3 = 14.9.

This calculation develops the minimum soil to debris ratio for 8 ft × 10 ft × 3 ft concrete monoliths. As shown in Figure 2-7, minimum spacing between monoliths is 10 ft to allow compaction of soil using a compactor.

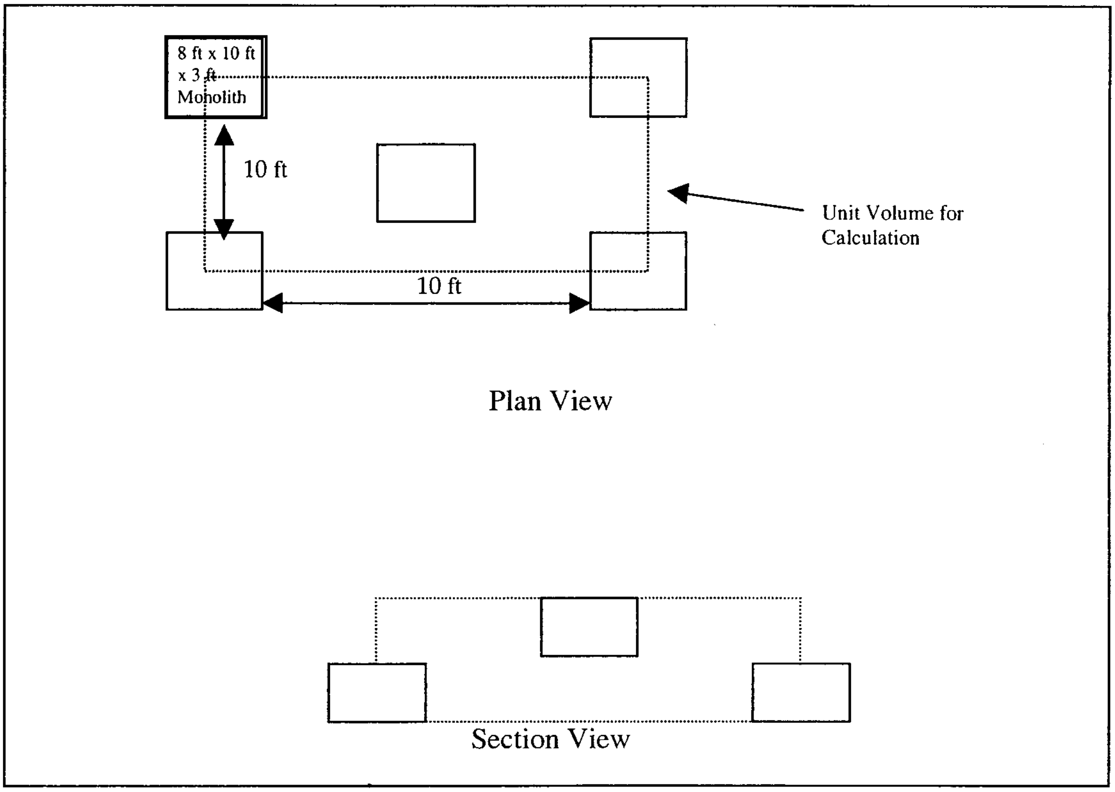

Figure 2-7. Plan and section views for concrete monolith.

Total unit volume for basis of calculation = (20 ft)(18 ft)(6 ft) = 2,160 ft^3

Total volume of debris within the total unit volume = (8 ft)(10 ft)(3 ft) + 4[(4 ft)(5 ft)(3 ft)]

Total volume of debris boxes = 480 ft^3

Total volume of soil = 2,160 ft^3 – 480 ft^3 = 1,680 ft^3

Minimum soil: Debris ratio = 1,680 ft^3/480 ft^3 = 3.5.

3. CONCLUSIONS AND RECOMMENDATIONS

Table 3-1 summarizes the total landfill volumes, soil volume, and debris and/or container volume for each of the different types of debris that were analyzed. This table is not meant to summarize or justify a stable waste fill, but the placement diagrams demonstrate access by compaction equipment and significant volumes of soil around containers based on maintaining a stable waste fill. The main intent of this table is to summarize the expected soil to debris ratios compared with the volumes anticipated for disposal at the landfill. Table 3-1 includes the waste volume that must be soil on the floor, sides, and top of the landfill. The placement diagrams presented in this EDF were developed based on achieving a stable waste fill. Based on the projected design inventory of debris anticipated at the landfill, Table 3-1 demonstrates that the projected debris volume is less than the available debris volume within the landfill.

Table 3-1. Summary of soil to debris volumes.

Debris Type	Total Landfill Volume (yd^3)	Total Debris Volume (yd^3)	Total Soil Volume (yd^3)	Soil to Debris Ratio	Design Inventory Anticipated Volume (yd^3)
4 ft × 4 ft × 8 ft Boxes	510,000	37,000	473,000	13 to 1	0[a]
4 ft × 4 ft × 4 ft Boxes	510,000	25,000	485,000	19 to 1	0[a]
Steel/Concrete Beams	510,000	130,000	380,000	3 to 1	0
Concrete Demolition Debris	510,000	50,000	460,000	9 to 1	0
Concrete Rubble	510,000	91,000	419,000	5 to 1	54,021
Drums	510,000	18,000	492,000	27 to 1	255
Concrete Monolith	510,000	73,000	437,000	6 to 1	0

a. Quantity does not include wooden boxes, which will be crushed during placement.

Based on the summary above, the soil to debris/container ratio for different types of debris/ container varies from 3 to 27 times more soil than debris. Assuming an equal mix of all these different types of debris/containers produces an average soil to debris ratio of 12.

It is recommended that debris be disposed during periods when significant volumes of contaminated soil are also available. During operations, advance notice of the types and quantities of debris/containers will be required in order to ensure the proper ratio of soil to debris/containers. This operations consideration has been incorporated into the waste profile acceptance process for debris and/or containers as identified in DOE-ID 2002b, *ICDF Complex Waste Acceptance Criteria.*

4. REFERENCES

DOE-ID, 2002a, *Waste Acceptance Criteria for ICDF Landfill*, DOE/ID-10865, Rev. 2, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho, May 2002.

DOE-ID, 2002b, *ICDF Complex Waste Acceptance Criteria*, DOE/ID-10881, Rev. 0, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho, May 2002.